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Application of the User Centered Design Framework – Case Study Using the Example of an AR Feature for a Mobile Shopping App

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Abstract – Augmented reality (AR) has become increasingly important in recent years and is already being used in many areas. AR is also increasingly penetrating the retail sector as a functionality of mobile apps. At the same time, companies must meet user requirements when developing AR features. This case study exemplifies how the User Centered Design framework (UCD) can be used to develop an AR feature for a mobile shopping app that can be used to virtually color walls in a room. To begin, the UCD will be introduced and compared to the New Product Development framework and the Information System Research framework. The four phases of the UCD and possible methods to be applied are discussed. One method per phase is then applied as an example. The results are shown and discussed.

Keywords – User Centered Design, Augmented Reality, Mobile Shopping App, Product Development

1 Introduction

The topic of augmented reality (AR) has already been in the focus of research for several years and in different contexts (Dacko, 2017; Masoni et al., 2017; Url et al., 2019). At the latest since teenagers generated billions of views on social media with AR-based filters and the smartphone game "Flappy Bird" can be controlled with the blink of an eye, AR has become tangible for many consumers (Eisenbrand, 2019). Accordingly, the willingness of many consumers to install an AR smartphone app or use AR data glasses is high (Splendid Research, 2018).

Despite this high relevance from the consumer's point of view, many companies have so far made little use of the possibilities offered by AR technologies (Econsultancy & Adobe, 2020). Opportunities such as AR-based dressing rooms in stationary retail are currently hardly widespread (Deckert & Wohllebe, 2021, p. 20). At the same time, AR, especially when integrated into a smartphone app, is shown to have high potential for increasing customer satisfaction (McLean & Wilson, 2019; Wohllebe et al., 2020). AR use

by consumers is expected to increase significantly in the coming years and become an essential part of the mobile ecosystem (Gentemann et al., 2018).

With the growing relevance of digitization, mobile apps are taking on an increasingly important role from the customer's point of view, along with many other challenges (Arimie & Oronsaye, 2020; BITKOM, 2020; Kheiravar & Richter, 2016; Ross, 2020). It must be emphasized that the development of mobile apps in general and AR-based apps in particular must always take into account the needs and requirements of the users. Recent research has shown that this is a major challenge for many companies, for example, in the case of apps in the context of retail or education (Papadakis et al., 2018; Wohllebe et al., 2020).

The goal of this paper is therefore to show how the conception and development of an AR feature for a mobile shopping app can be aligned with the needs of potential users using the User Centered Design Framework (UCD).

For this purpose, current findings on augmented reality from literature and research are first considered (cf. Related Literature section). Then, the UCD is presented and compared with the New Product Development Framework (NPD) and the Information System Research Framework (ISR) (cf. Framework Overview section). Finally, the example of an AR feature to be conceptualized for a mobile shopping app is used to show how the UCD with its four phases can be used in practice with the inclusion of concrete methods (cf. Results section). The results are summarized and discussed.

2 Related Literature

If reality is extended by virtual objects that are projected into the field of vision of users and enable them to interact with the objects, this is referred to as AR. Because AR glasses have not been widespread to date, AR is now mainly used on smartphones in the form of apps. AR is already being used in the entertainment and games industry in particular (Borgmeier et al., 2017). Arguably one of the world's most popular AR-based apps is the game "Pokemon Go" (Lill, 2016).

In the retail sector, too, and in e-commerce in particular, there are now initial use cases for AR that have also been considered scientifically. AR-based applications, for example, offer users the opportunity to virtually project products into an environment they are familiar with. Particularly when shopping for furniture, clothing, shoes, or jewelry, this is potentially considered helpful (Lu & Smith, 2008). Consumers not only find the "try before buy" option informative and enjoyable, it also increases their willingness to share personal data and their purchase intentions (Smink et al., 2019). Personalization takes a critical role in this and has a positive impact on consumer responses to AR (Smink et al., 2020). In this way, AR also strengthens the bond with a brand and improves the shopping experience (Deckert & Wohllebe, 2021, p. 20; McLean & Wilson, 2019).

For a positive user experience ("joy of use"), app developers must ensure good usability, appropriate content, and a consistent look and feel. In the case of mobile apps - also in the AR context - this also includes, for exam-

ple, fundamental considerations such as the operating mode of a smartphone (landscape vs. portrait, one-handed vs. two-handed) or the limited action radius of the thumb (Semler & Tschierschke, 2019). In the specific context of AR apps, the performance of the end device, the refresh rate, the required size of the room or the level of detail of the displayed objects also play a special role (Babich, 2020; Dirin & Laine, 2018; Endsley et al., 2017; Werrlich et al., 2017).

3 Framework Overview

In the following, the UCD is presented first. This will be applied in the further course to conceptualize the AR feature. In addition, the NPD and the ISR are briefly introduced and compared with the UCD (cf. tbl. 1).

The UCD is used for the development of interactive systems and puts the needs of the user in the foreground. It can be included in various environments, such as object-oriented, waterfall or agile development. (Hevner, 2007). The UCD is particularly relevant because it is also mentioned in the corresponding ISO standard on "Ergonomics of human-system interaction" (*DIN EN ISO 9241-210*, 2020).

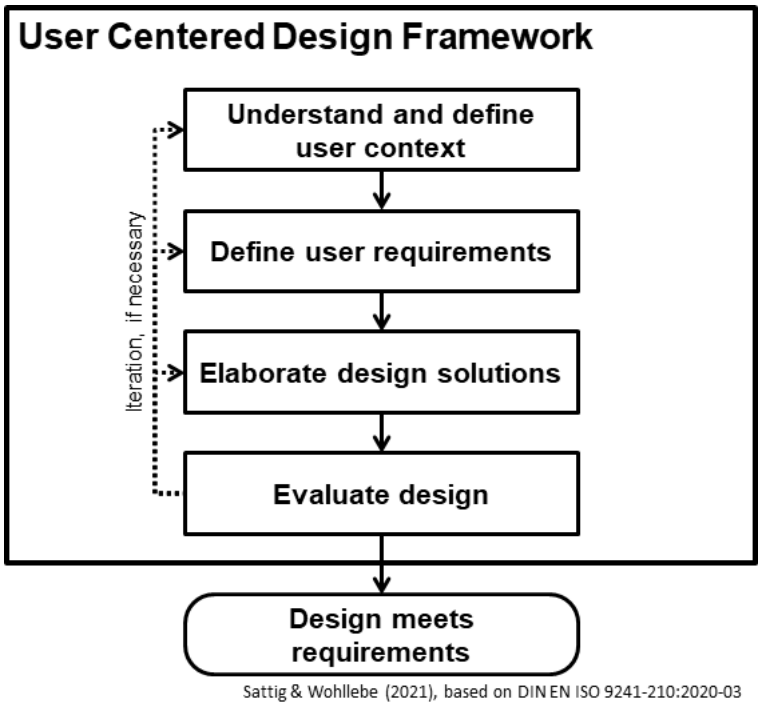

Figure 1: User Centered Design framework – process overview

UCD requires that all stakeholders of a function with their characteristics, tasks and environments are identified before the actual development begins. Of central importance is the repeated, active involvement of users in the

process. This results in the necessity of an iterative procedure, which enables repeated testing and revision of the developed intermediate states.

The UCD can be divided into four phases (cf. fig. 1):

- Understand and define user context
- Define user requirements
- Elaborate design solutions
- Evaluate design

After the evaluation, it is possible to jump back to any of the three previous phases and go through a new iteration. If the evaluation is successful and the user requirements are met, the final development can be started (*DIN EN ISO 9241-210*, 2020).

This is contrasted with the NPD. This is not iterative, but is based on a linear process in five steps. After developing a new product strategy that includes all requirements, at least seven ideas are to be generated for each product. These are then to be examined with regard to their economic viability, then designed and developed, and finally tested (Bhuiyan, 2011).

The third framework to be mentioned is the ISR. It contains definitions, boundaries and guidelines on how information systems or information processing systems are to be designed. ISR is based on three interrelated cycles. The relevance cycle links the environment to design science research. The design cycle builds and evaluates concrete design and processes. The rigor cycle connects design science research and knowledge base. Each cycle and the ISR as a whole is an iterative process.

Table 1: Comparison of UCD, NPD and ISR framework (Sattig, 2021)

	UCD	**NPD**	**ISR**
Flexibility	Medium	Low	High
Iterative	Y	N	Y
User Analysis	Y	N	Y
No. Phases	4	5	3
User Involvement	Y	Y	Y
Exact Process Description	Y	Y	N
Including Possible Methods	Y	N	N

Because the NPD is a framework that provides clear structures and defined processes, but AR-based functionalities are not yet widespread and concrete user requirements are therefore not known in principle, the NPD does not appear suitable - also and in particular against the background of the thoughts on agile working (Alsaqqa et al., 2020; Kendall et al., 2010; Wohllebe, 2021).

Table 2: Possible methods for applying UCD (ISO/TC 159/SC 4, 2007)

Method	Direct User Involvement	Short description
User observation	Y	Systematic, accurate collection of information about user behavior in the context of specific tasks.
Performance-related methods	Y	Collection of quantifiable performance measures to understand the impact of usability problems.
Analysis of critical incidents	Y	Systematic collection of positive and negative events.
Questionnaires	Y	Indirect evaluation methods, collecting users' opinions in predefined questionnaires.
Interviews	Y	Similar to questionnaires, with greater flexibility and personal interaction with the respondent.
Thinking aloud	Y	This involves users continuously verbalizing their ideas, beliefs, expectations, doubts, discoveries, etc. while using the system under test.
Collaborative design and evaluation	Y	Methods by which different types of participants (users, product developers, and specialists) can collaborate in evaluating or designing systems. Usually involving users.
Creativity methods	Y/N	Methods that identify new products and system features, usually extracted from group interactions. In the UCD context, members of such groups are often users.
Document based methods	N	Review of existing documents by a usability expert to obtain a professional assessment of the product.
Model-based approaches	N	Use of models that are abstract representations of the assessed product to predict user performance.
Expert interviewing	N	Evaluation based on the knowledge and practical experience of the usability expert.
Automated evaluation	N	Algorithms identify shortcomings of the product with respect to predefined usability criteria.

Although UCD and ISR share many similarities (iterative approach, user analysis, user involvement), ISR lacks a concrete approach to developing functionality. In particular, the reference to possible methods in the implementation of the framework argue for an application of the UCD in the de-

velopment of AR-based functionalities. In fact, the UCD has been applied in the past to the development of an AR feature in the context of interior design, and a variation of the UCD has been applied in the context of an AR-based gaming platform (Sattig, 2021; Siltanen et al., 2013; Simão & Bernardino, 2017).

4 Results

The following shows the use of UCD to design an AR feature for a mobile shopping app. The feature is intended to allow users of the retailer's app to select a wall color and use it to virtually "paint" a wall in their home. This is intended to give users a better idea of how the selected wall color would look on their wall at home.

The ISO/TR 16982 technical report proposes several usability methods in the context of using the UCD. Each of these methods supports the goals of the UCD. Table 2 lists these methods as the most commonly used and briefly characterizes them.

An online questionnaire is used **for the first phase** of the UCD, which is to understand and define the user context. The methods have already been applied in similar contexts (Devi et al., 2012; Goldfarb & Tucker, 2011). In a pre-test, the internal validity is first checked. Then the survey is sent via push notification to users of the mobile app who have been interested in corresponding assortments in the past. This increases the tolerance of the users to the push notification and has a positive effect on the response rates (Menold, 2015; Wohllebe, 2020).

A total of 612 responses are collected. 346 respondents answer the questionnaire completely. Incomplete answers are also included in the evaluation.

65 percent of respondents say they are not familiar with AR as a technology. Regarding the use of AR-based apps, 60 percent say they never use AR-based apps. Fifteen percent use them several times a year, 12 percent use them several times a quarter, and 12 percent use them several times a month. Respondents cite ease of use, high information content and detailed instructions as the most important features of AR features. The evaluation of the free text field also reveals that users want a high degree of fidelity to reality.

In the second phase, the users' requirements are to be defined with the help of a creativity method. For this purpose, focus groups or group discussions are used, which have already been applied in similar contexts in the literature (Cox et al., 1976; Devi et al., 2012). Due to the Corona pandemic, the execution takes place remotely. Participants turn on their cameras. Audio and video are recorded for better evaluation.

The facilitation concept includes three phases. First, users report their previous experiences with AR and the envisioned feature is presented to them. Then, users describe their first impression of the feature. In the third phase, brainstorming takes place. Users are instructed to express all ideas.

Apart from comprehension questions, no comments are allowed. In addition, an online tool is provided for users to make sketches.

Ideas that emerge from the brainstorming include the following:

- App should point out trend colors
- Inspiration for design should be made available
- Possibility to upload a photo should exist
- Possibility to calculate the amount of paint required based on room size
- Color should be available for direct purchase online
- Expert support should be available via chat
- Favorite colors can be saved
- Hints for well-matched colors shall be given
- Color codes for mixing the color shall be provided
- Image of virtually painted wall to be saved and shared

Focus group participants are then given to prioritize the ideas expressed in the brainstorming session. To do this, each participant can assign 100 points to the ideas generated. The top five features, in descending order, are:

1. Get color codes to mix color
2. Buy color directly
3. Save color for later
4. Share picture of virtually colored wall
5. Search colors from catalog

At the end of the second phase, the requirements are consolidated. Design heuristics, the results from Phase 1, the results of the group discussions, the design of the existing app, the design of other AR apps, and the company's corporate design guide are considered.

The elaboration of the design solution is done **in the third phase** with a collaborative design. In the course of the design process, short interviews are repeatedly conducted with potential users in order to involve them accordingly (Crespi, 1964; Devi et al., 2012; Schreier et al., 2012). Among other things, scribbles, mock-ups and, as the project progresses, an increasingly detailed prototype are used (Devi et al., 2012; Rodrigues et al., 2017; Tobias & Spanier, 2020). Several hand-drawn scribbles are the starting point to meet user requirements. The scribbles are discarded or refined piece by piece. Then, slightly more detailed, digitally created wireframes are used and linked on a storyboard. Then a prototype is created.

In the fourth phase, the design solution is evaluated. User observation is used for this purpose. Potential users are observed in a synchronous remote usability test. If necessary, questions are asked (Baravalle & Lanfranchi, 2003; Wozney et al., 2015). Users use the prototype on their own smartphone, and the screen is transmitted to the interviewer. Users are asked to solve some prepared tasks, including.

- Color room live in pink and read out color code
- Color room in blue based on a photo of the room from their own photo gallery
- Color room in green and enlarge color to the whole screen
- Add green and blue to the favorites list and delete them again

During usability testing, user feedback is documented, then reviewed and implemented. For example, there are suggestions for improvements to the operation and content of the introduction. Also, a button to submit the search query for a color is apparently missing; pressing Enter is not intuitive for the user.

The prototype is finally finalized based on user feedback and handed over for programming.

5 Summary and Conclusion

The goal of this paper was to show how an AR feature for a mobile shopping app can be designed in a user-oriented way. As an introduction, it was first briefly explained on the basis of existing scientific findings to what extent AR technology can help (retail) companies and what requirements users have. Subsequently, three different possible frameworks were presented and evaluated to what extent they are suitable for designing a user-oriented AR feature for a mobile shopping app. The UCD was thus identified as particularly suitable and methods for applying this framework were presented. The results show which methods were applied in the specific case at hand and how, and what insights could be gained for the design process.

For further research, it is suggested to address in particular the choice of the concrete methods. In particular, this may concern the question of which methods are particularly suitable under which circumstances in order to meet the goal of the framework - the user-centered design of technology in the broadest sense.

Overall, the case study shows that UCD is suitable for involving potential users of a feature early in the development process. In particular, it should be mentioned that the insights gained from early user feedback definitely bring advantages from the company's point of view because the product-market fit can be better ensured.

6 Authors

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